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EVOLUTION

A JOURNAL OF NATURE

HARLOW SHAPLEY

Scientific Advisory Board

Henry E. Crampton
Martin Dewey
Wm. King Gregory
Paul B. Mann
Elihu Thomson

EVOLUTION

A Journal of Nature

For popular education in natural science to combat bigotry and superstition and develop the open mind

Science Editor
Allan Broms

Managing Editor
L. E. Katterfeld

Contributing Editors
Edwin Tenney Brewster
Maynard Shipley
Horace Elmer Wood II.

A NEW CHAPTER BEGINS with this issue. A number of most eminent scientists have consented to act as members of a Scientific Advisory Editorial Board; Prof. *Henry E. Crampton*, head of the Zoology Department in Barnard College; Dr. *Martin Dewey*, President-elect of the American Dental Association; Dr. *Wm. King Gregory*, Professor of Vertebrate Palaeontology at Columbia University and Curator of Ichthyology at the American Museum of Natural History; Dr. *Paul B. Mann*, President of the New York Association of Biology Teachers; Dr. *Elihu Thomson*, Consulting Engineer of the General Electric Company.

MORE THAN TWENTY THOUSAND new readers are expected to receive this issue of EVOLUTION. As an introduction we therefore state again our aims: The purpose of EVOLUTION is to combat bigotry and superstition by popularizing natural science; to replace dogmatism with the scientific method; to champion the right of schools to teach whatever science discovers, and to maintain the duty of teachers to do so no matter how this conflicts with preconceived prejudice; to achieve a larger place for science in education; to develop a general interest in natural science among the people, and to encourage the growing sense of social responsibility among scientists. For the attainment of these ends we invite the active co-operation of every reader.

A CERTAIN PROFESSOR HAS REFUSED to renew his subscription because "the name, Evolution, is too radical. The very word, evolution, antagonizes. It does more harm than good." This same professor has written a biology text book without mentioning evolution and actually boasts of its approval by fundamentalist school boards.

Such a professor, no matter how eminent, is a disgrace to his profession. For the fundamentalist who opposes teaching evolution because he honestly believes that the eternal welfare of his children is involved, we have respect and sympathy even while we attack his illusions. But for a scientist, who *knows* evolution to be a fact, yet deliberately bears false witness in order to sell more of his books, we have no regard at all.

It may be "good business" to please backward school-boards in this way, but it is not honest. To hide the truth because of fear of opposition is moral cowardice. To hide it out of regard for profit is intellectual dishonesty. Instead of feeling proud of it and pressing us to follow his example, the professor should feel the blush of shame upon his cheeks.

No—Evolution will not resort to such subterfuge. Evolution will not equivocate, will not compromise, will not trim and hedge and hide. Evolution will always come out boldly with the facts. Naturally, those that prefer mental bootlegging to this straight forward policy, will refuse their support. But this very condition proves the necessity for Evolution and makes us all the more determined to give the solid grain of science instead of merely science husks. And we're confident that enough of our readers have the necessary moral integrity to help us "carry on" until the pressure of organized superstition, before which the professor has yielded, disappears from the face of the earth. L. E. K.

WHAT DARWIN'S LIFE HAS MEANT

If I were called upon to express what his life has meant, I should answer, "He destroyed the raging faith of the human brain that it can attain truth by logic." It is this faith which inspires us to interpret nature as if it were answerable to human reason, as if it must be clothed in "design" or "purpose" or "rectigradation." Darwin is slowly teaching the world that nature is utterly beyond our thinking and that we are absurd if we drape it in our mental tatters. We are rational only when we try to observe nature in Darwin's way.

But I feel as if the stern old humorist were standing by my desk and were not quite happy about my simile. A better summary of his work is given in a sentence that he wrote in 1842, in the scribbled first sketch of his theory. It suggests how Newton rescued the human mind from its welter of superstition about personality in inorganic nature. Newton showed that all matter is subject to regular laws. But organic nature still remained beyond law, a field for a riot of superstition. Darwin, in his study, concluding his first sketch of an evolution theory, set down his hope of the good it might accomplish —that it might make the facts of living matter intelligible. And he made a parable for his hope:

"We no longer look on an animal as a savage does at a ship."

—Henshaw Ward, in "Charles Darwin: The Man and His Welfare."

IN OUR NEXT

March Evolution *will bring several noteworthy articles:—*

Ales Hrdlicka of the Smithsonian Institution on the Human Race and Its Future.

Wm. King Gregory on the recent expedition of the American Museum of Natural History to the gorilla country.

J. H. McGregor of Columbia University, the latest information regarding the "Peking" Man.

H. Gideon Wells of the University of Chicago, on the new evidence for evolution from Bio-Chemistry and Immunology.

H. J. Muller, concluding "How Evolution Works."

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The Range of the Universe

By HARLOW SHAPLEY

THE galaxy-hunting astronomer may appear to be a rare spirit, blessed with the privilege of associating always with grand affairs—big stars, long distances, great spaces. But he does not greatly delude himself. His is also a world of littleness. His first sidereal measurement takes him out of touch with dimensions galactic to the minutest of things. To measure he must see. To see he must have light. To have light he must be in contact with the infinitesimals of the sub-microscopic world.

There is no avoiding electrons, whose diameters are a millionth of a millionth of millionth of a mile, when we measure the galactic system, whose diameter is a million, million, million miles. We need to consider the behavior of the individual radiating mechanism, consisting of one atom, when we analyse the behavior of an individual radiating star composed of more than 1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000 atoms. Stars and atoms must be taken together, light waves and light years, electron motions and drifts of galaxies.

A survey of material systems will therefore remain rightly in the astronomer's field when it includes clusters in which the units are stars, and atoms in which the units are corpuscular electrons and protons. The astronomer continually goes to the physical laboratory for guidance in theory and for experimental facts; the physicist frequently goes to the stars for inspiration and for data.

It is our ambition to start at the bottom and work our way up in the world. We shall therefore begin with electrons . . .

We have no right whatever to maintain doggedly that we have reached the ultimate in infinitesimal material systems when we deal with these familiar material units. Experience should quickly teach us how unsafe such an assumption would be. A few decades ago not even the atom would have been admitted to the society of systems. Atoms were the little, hard, ultimate chunks of matter, indivisable by grace of name and experiment and scientific dogma. But atoms are no longer listed as ultimates, they are now among the best of material systems; and even their unit components cannot maintain the former atomic role of being the indivisable stones from which the material universe is built. Experience certainly recommends caution in asserting any lower limit in the organization of the microcosmos.

On the other hand, since we can know of electrons and protons and the units of radiation only by using electrons and protons and units of radiation in our technique of measuring and comprehending, it may be that we have already got near the bottom of measurable units and systems of units. Light waves and electrons can be rather handily used to measure those bodies and systems of bodies in the material world that are larger than electrons and light waves. In the relatively coarse-grained world in which we are to work, they are efficient tools. But in the hypothetical sub-electronic world, where there may be systems within systems indefinitely, our coarse-grained tools no longer bring information to our coarse-grained minds. It may be that we are stopped in our explorations downward, not because the limit is reached, but because of our inherent awkwardness.

To register our conviction that the series of systems extends downward, and that for us its limit is indeterminate, we shall start our list of material systems with an empty dotted line, and give it the class number —5. The first recognizable systems, therefore, have the number—4. These small entities may be appropriately given the generic name Corpuscles, and we start out thus:

— 5 . . . . . .
— 4 Corpuscles
— 3 Atoms
— 2 Molecules
— 1 Molecular Systems
0 Colloidal and Crystallic Aggregates
+ 1 Meteoric Associations
+ 2 Satellitic Systems
+ 3 Planetary Structures
+ 4 Double and Multiple Stars
+ 5 Galactic Clusters
+ 6 Globular Clusters
+ 7 Galaxies
+ 8 Multiple Galaxies
+ 9 Supergalaxies
+10 The Metagalaxy
+11 The Cosmoplasma
+12 The Universe (Space-Time Complex)
+13 . . . . . .

Let us indulge one idle fancy. Is our inability to get deeper into the minutiae of the microcosmos or, in the other direction, farther into trans-galactic space tied up somehow with our own dimensions? It is a singular fact that electrons, in diameter, are just as much smaller than a man as he is smaller than a supergiant red star, the biggest body he measures. The observer is thus geometrically near the middle of the range. Also, in material content he is in a middle position. The biggest definitely organized and closely coherent bodies we measure are these giant stars that contain about 10^{58} corpuscles (electrons and protons). An average man's body contains 10^{29} corpuscles—halfway down towards the unit electron.*

If the observer and interpreter were as large as Betelgeuse might he fail in his survey to reach objects smaller than the meteors and moons, but perhaps go far beyond our metagalactic system in the direction of things extensive? Or if he were of the dimensions of a bacterium, might not the sub-electronic world open up easily, though he fail to comprehend or measure the stars and larger parts of the sidereal universe?

Excerpts from "Flights from Chaos" by Harlow Shapley, with permission of the author and publisher. Copyright, 1930, by the McGraw-Hill Book Co., Inc. New York, N. Y.

*The exponent figures indicate that ten is to be used that many times in multiplying. If the exponent figure is preceded by a minus sign, ten is to be used that many times in dividing. This device saves writing a long series of ciphers, 10^{58} meaning 1 followed by 58 ciphers.

If, however, the technique of measurement and understanding always involves light of the wave lengths and properties we know about, a displacement of the observer from the middle of the scale does not help in penetrating the cosmos. Bacterium or Betelegeusian—he finds that the tools, not the vision, set the limits, or at least constitute the handicap. New tools are needed, not a dimensional displacement of the observer.

Our pivotal position in the scale of dimensions is probably just another of the grim illusions that make man appear to be importantly in the midst of the measureable world. As with his once flourishing geocentrism, further research may again easily decentralize him. We can attach no cosmic significance to his position in the universe. We are, as remarked above, indulging vain fancy . . .

Comprehensive and final, the word Universe seems most obvious for the name of our ultimate class . . . In our present usage, the Universe includes every material thing we know. Is it not natural and appropriate therefore to terminate the survey at this point, with the classes running from —4, Corpuscles, to +12, The Universe?

If a hundred years ago we had surveyed the systems within the universe as then comprehended, it is certain that at both ends the list of recognized material systems would have been more limited. Atoms were not treated as systems, but as units. Electrons were unknown. In the macrocosmos there were vaguely understood galaxies, but nothing higher was definitely visualized. Very little was accurately known, of course, concerning sidereal distances or stellar population. The warning of scientific history is certainly that our growing knowledge of The Universe may soon cross present boundaries, and that we should allow for systems beyond those now conceived. Scientific pronouncements concerning unsurpassable limits in dimensions and masses or ultimates in organization are likely to be mere dogma.

I suggest, therefore, that Class +13 . . . be set up, partly as a matter of safety, partly as a challenge.

Numbers of Particles

Hydrogen atom	2
Mercury atom	400
One gram	10^{24}
Comet	10^{44}
Earth	10^{52}
Sun	10^{57}
Globular Cluster	10^{63}
Galaxy	10^{67}
Supergalaxy	10^{68}
The Universe	$>10^{73}$(?)

Diameters of Material Systems

	cm
Proton	10^{-13}
Atom	10^{-8}
Molecule	10^{-7}
Colloid	10^{-6}
Comet and Meteor Stream	10^{7}
Earth-moon System	10^{11}
Solar System	10^{15}
Galactic Cluster	10^{19}
Globular Cluster	10^{20}
Star cloud and Galaxy	10^{22}
The Galactic System	10^{23}
The Metagalaxy	10^{27}
The Universe (radius)	10^{29}(?)

Evolution of Insects

By F. M. CARPENTER

THE insects occupy the same position among the invertebrates that the birds do among the vertebrates: they are the sole members of their respective series to develop true wings. But the insects have undergone more changes in structure in adaptation to their surroundings and modes of living than any other animal forms. Most of them are winged and strong fliers; many possess oar-like legs and swim in lakes and streams; others have legs shaped like shovels and live in the soil; and a few others have lost all appendages and live within the body of some animal, feeding on the tissues and body fluids. Such a diversity of structure is an indication of great age and implies that much modification or evolution has taken place within the group.

From numerous investigations on fossil insects it is certain that as far back as the middle Tertiary period (about fifty million years ago) the insects had already reached a development as specialized as that of the living species. Most of the genera, or species-groups, of the Tertiary are still existing. It is interesting to find that nearly all these genera once lived in different regions of the earth than they do now. The Tse-tse fly (*Glossina*), which carries the dreaded African "sleeping sickness," now restricted to the Old World tropics, inhabited the Colorado region during the mid-Tertiary.

If we go back to the middle Mesozoic (about 150 million years ago), we find a stranger assortment of insects; some of the existing families were present, but most of the species were less complex in structure than the modern or Teritary ones.

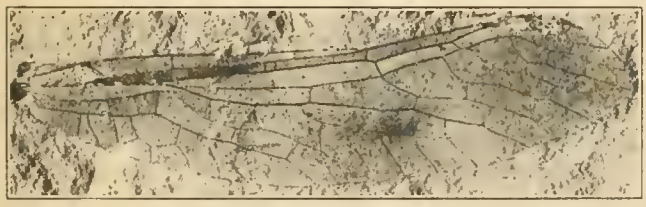
When we go back to the Permian period (about 200 million years), we can find no living families, although there are several familiar orders, the cockroaches, dragon-flies, scorpion-flies and such primitive types. The Permian insects, however, were more primitive in most respects than their existing relatives.

Now if we turn over another page of our geological calendar, we come to the Upper Carboniferous (about 250 million years), in which the first insects are found. Only in the top layers of these strata do we find an existing group of insects, —the cockroaches; all the other species, especially those of the lower beds, belong to orders which have long since become extinct. They possessed none of the modifications or specializations which characterize our modern forms. The three segments of the thorax were equal in size and shape, showing no differentiation; whereas in living insects the two segments which bear the wings have become enlarged by, or for, the expansion of the muscles within. In other groups of recent insects, such as the leaf-hoppers, the first segment of the thorax possesses elaborate spines or some other form of armature.

1. A member of the extinct order Prodonata from the Permian of Kansas. Existed only during Carboniferous and Permian. Some were more than 2½ feet across the wings.

Similarly, the wings of these Carboniferous insects were unspecialized; the hind pair were of the same size and shape as the front pair, and the veins were alike. As we follow the insects through the geological ages we can trace the evolution of the peculiar features of the modern species. In some groups, such as the grasshoppers and allies, the hind wing has increased in size at the expense of the fore wing; in other groups, such as the may-flies, the hind wings have become smaller and smaller, while the front pair have enlarged. In the Permian may-flies, for example, the wings were just alike, in the Mesozoic species the hind wings were a little smaller than the fore, and in all existing species the hind wings are so small as to be almost useless for flight,—in some they have been entirely lost.

Of course, as the size and shape of the fore and hind wings became different in these groups of insects, their venation was



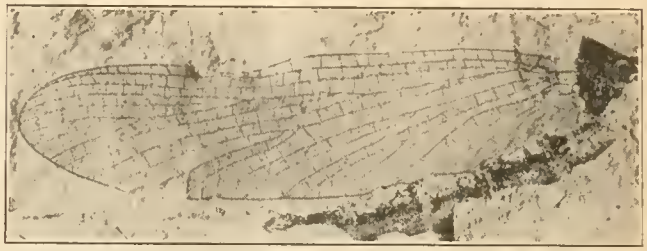
2. Primitive Dragon-fly from the Permian of Kansas; (specimen in Harvard Museum of Comparative Zoology). Note that none of the specialized features of later dragon flies are present.

also modified; so that in living insects the veins of the fore wing follow a different arrangement from those of the hind wing. The evolution of these changes can be traced in the fossils. Again, in the Carboniferous insects the veins were distributed equally over the wings, but gradually assumed other positions as the wings themselves changed in shape or mode of operation. The predatory insects, for example, in which the ability to fly rapidly was essential, developed peculiarities in the veins which strengthened the wing membrane for powerful strokes.

Recent investigations on fossil insects have filled in many of the gaps in the geological history of these creatures, so that we are able to obtain a bird's-eye view of their evolution from a consideration of the geological ranges of the major groups, or orders. Most of the insects of the Carboniferous and Permian were of orders dying out before the middle Mesozoic.

The cockroaches, or at least insects which were like them, but a little more primitive, have existed since the Upper Carboniferous; but they have undergone considerable modification in structure and the number of species has greatly increased. In the Carboniferous the cockroaches comprised nearly 60% of all the species, but they steadily died off during the geological ages until now they make up less than a half of one percent of the existing insects.

In the Permian we find a few other living orders,—the dragon-flies (*Odonata*), May-flies, scorpion-flies, Neuroptera,



3. Primitive May-fly from Permian of Kansas. The wings of these insects were alike, but in existing species the hind wing is less than one-third as large as the front one.

true bugs (*Homoptera*), and the bark-lice (*Psocoptera*); but they were all much simpler than the later types and belong to extinct families. In the Mesozoic the wasp group (*Hymenoptera*) makes its first appearance, as well as the caddis-flies, thrips, and the heteropterous bugs, and the ear-wigs. In the Tertiary we find the white ants (*Isoptera*) and butterflies (*Lepidoptera*) for the first time.

The significant fact concerning this sequence of insect groups in geological time is that the groups appear in the same chronological order as we should expect from a study of the structures of their living representatives. The primitive orders appear first, followed in turn by more highly specialized members until the present complex, intricate insects developed.

4. Dragon-fly from the Mesozoic of Bavaria. Note how much more complex the veins are than in the Permian specimen. (Fig. 2.)

BROMS ON THE AIR

Allan Broms, Science Editor of EVOLUTION, speaks over the radio regularly three times a week as follows:

Saturdays, 11:30 A.M. Station WOR
Saturdays, 5:00 P.M. Station WEVD
Sundays, 2:00 P.M. Station WPAP

Some of his subjects this month are: "How Big Is The Universe?" "Blood Will Tell," "What Is The Sun Made Of?" "History In A Tree Trunk," etc. Listen in with your friends and write your impressions to these radio stations. If Natural Science radio talks are appreciated, there will be more of them.

Man's Day Begins

By SIR JAMES HOPWOOD JEANS

ANTHROPOLOGISTS and geologists tell us that man has existed on earth for something like 300,000 years; we must go this far back to meet our ape-like ancestry. Between them and us some 10,000 generations of men have walked the earth, most of whom have probably given some thought, in varying degree, to the significance of their existence and the plan of the universe.

Sir James Jeans

Of these 10,000 generations of men, the first 9,990 unhesitatingly regarded the earth as the center, and terrestrial life as the central fact, of the universe. As was suited to its majesty and dignity as the abode of man, the earth stood still while the celestial sphere spun around it, covering in the earth much as a telescope dome covers in the telescope; and this dome was spangled with stars, which had been thoughtfully added so as not to leave the central earth unilluminated at night. Ten generations at most have been able to view the problem of their existence in anything like its proper astronomical perspective.

The total age of the earth far exceeds the 300,000 years or so of man's existence. The evidence of geology, and of radioactivity in rocks in particular, shows that it must be something like 2,000,000,000 years, which is several thousand times the age of the human race. Old Mother Earth must regard man as a very recent apparition indeed; he has just appeared to burrow into her, burn her forests, put her waterfalls into pipes, and generally mar the beauty of her features. If he has done so much in the first few moments of his existence, she may well wonder what is in store for her in the long future ages in which he is destined to labor on her surface.

For in all probability the life in front of the human race must enormously exceed the short life behind it. A million, million years hence, so far as we can foresee, the sun will probably still be much as now, and the earth will be revolving round it much as now. The year will be a little longer, and the climate quite a lot colder, while the rich accumulated stores of coal, oil, and forest will have long been burned up; but there is no reason why our descendents should not still people the earth. Perhaps it may be unable to support so large a population as now, and perhaps fewer will desire to live on it. On the other hand, mankind, being three million times as old as now, may—if the conjecture does not distress our pessimists too much—be three million times as wise.

Looked at on the astronomical time scale, humanity is at the very beginning of its existence—a new born babe, with all the unexplored potentialities of babyhood; and until the last few moments its interest has been centered, absolutely and exclusively, on its cradle and feeding bottle. It has just become conscious of the vast world existing outside itself and its cradle; it is learning to focus its eyes on distant objects, and its awakening brain is beginning to wonder, in a vague, dreamy way, what they are and what purpose they serve. Its interest in this external world is not much developed yet, so that the main part of its faculties is still engrossed with the cradle and feeding bottle, but a little corner of its brain is beginning to wonder.

Taking a very gloomy view of the future of the human race, let us suppose that it can only expect to survive for 2,000,000,000 years longer, a period about equal to the past age of the earth. Then, regarded as a being destined to live for threescore years and ten, humanity, although it has been born in a house 70 years old, is itself only 3 days old. But only in the last few minutes has it become conscious that the whole world does not center round its cradle and its trappings, and only in the last few ticks of the clock has any adequate conception of the size of the external world dawned upon it.

For our clock does not tick seconds, but years; its minutes are the lives of men. A minute and a half ago the distance of a star was first measured and provided a measuring rod for the universe. A quarter of a minute ago, Hertzsprung and Shapley showed how the peculiar stars known as Cepheid variables provide a longer measuring rod, and taught us to think in distances so great that light takes hundreds of thousands of years to traverse them. With the last tick of the clock, Hubble, using the same measuring rod, has found that the most remote objects visible in the biggest telescope on earth are so distant that light, traveling 186,000 miles a second, takes about 140 million years to come from them to us. * * *

Our * * * infant, mankind, has made the great discovery of the existence of the outer world, has formed some conception of his size, and adjusted his ideas, not by a process of slow revelation, but by a brain flash of the last few seconds. In his mature years and his staid old age he is no doubt destined to make many sensational discoveries, but he can never again live through the immortal moments at which he first grasped the immensity of the outer world. We only live through a few ticks of his clock. * * * The wonderful thing is that fate has selected for us what is, perhaps, in some ways the most sensational moment of all the life of our race.

A high promise for future human achievement is here suggested by an eminent physicist. In the next issue, in an article on "WHAT IS MAN BECOMING?", Ales Hrdlicka will discuss Man's probable physical future from the viewpoint of an anthropologist.

From Annual Report of Smithsonian Institution, 1929. pp. 165-8.

SCIENCE LEAGUE OF AMERICA

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Is Man Blood-Cousin to the Ape?

By MAYNARD SHIPLEY

Another "confession" of an evolutionist turns out to be a misquotation. The Fundamentalist Reverend W. B. Riley quoted the author of this article as admitting that "man has a line of descent of his own, and not connected with any other species." What Mr. Shipley really said—something very different—is here told.

MANY persons become indignant when it is suggested that man is probably a distant cousin to the ape. Let us see.

Scientists of the University of Cambridge and elsewhere carried out extensive and careful experiments with a view to testing the conclusions of comparative anatomists and geologists relative to the descent and relationship of the various genera and species of animals, including man and the higher apes.

Some three million years ago, primitive lemurs abounded in the region now known as Wyoming and New Mexico, also in certain parts of France, as is attested by their fossil remains. Many zoologists believe that the monkey family originated in western North America, later spreading from this region to Europe, Africa and Asia, as in the case of camels and the rhinoceros family, which are almost certainly of American origin. The lemurs are now abundant only in Madagascar, but are found in small numbers in the tropical forests of Africa and Malaysia.

This line of descent of the man-like apes from the lowly lemur can be established by various lines of evidence as reasonably certain. It can also be shown that man himself has descended from the same common ancestor as gave rise to the man-like apes, and is, moreover, a veritable blood relative of the great apes. To test this theory in the light of blood immunity and blood relationship was one of the tasks set for themselves by Professors C. H. Nuttall, G. L. Graham-Smith, and T. S. P. Strangeways, all of Cambridge.

So long ago as 1875, Landois had shown that the introduction of the blood of a foreign species into any animal resulted in the disintegration of the minute, disk-shaped corpuscles, or cells, which float in the watery fluid (serum) of the blood. It was found that the serum of one family of animals (but not one species) destroys the cells of another. Thus, the blood of the wolf or the fox may be transfused into the dog, (or vice versa), or the hare into the rabbit, or the horse into the donkey, without dissolving the cells. The cells are dissolved if blood of two species not closely related is so transfused.

Friedenthal later showed that human blood serum dissolves the red blood corpuscles of fishes, amphibians, birds, such mammals as the cat, horse and even the lower monkeys; but *not* the cells of the anthropoid (man-like) apes! Finding that the blood of the chimpanzee and of the human can be transfused with impunity, this experimenter concluded that this fact proved the four manlike apes and human beings are *blood relatives*, since the blood cells of all animals not closely related are destroyed or injured in proportion to their relationship.

During the years 1897-99, the so-called "precipitin reaction" test was discovered and developed by Kraus, Tchistowitch and Bordet, and by this new method the monumental researches were carried on at Cambridge by Nuttall and his associates, on a quantitative basis, establishing the degree or closeness of relationship of nearly all genera of animals now living.

Omitting details, it may be explained that the precipitin reaction consists in the fact that if the colorless part of the blood, which remains after clotting, be taken from a human being, and injected into the veins of a rabbit, the blood serum of the latter will develop an anti-body, analagous to the anti-toxin which is produced in the blood of a horse by the injection of diphtheria virus. After several such injections, and a few days after the last injection, if the rabbit is killed and bled, the serum taken can be shown to be an "anti-human" serum. When brought into contact with human blood it causes the formation of a white precipitate; but if the foreign blood is that of some mammal only distantly related to man, the reaction is very feeble, exhibiting only a certain cloudiness. *But* if the foreign blood is that of a chimpanzee, gorilla, orang-utan, or gibbon, the precipitate *is* thrown down!

The *amount* of the precipitation is a measure of the closeness or distance of relationship. Passing from the manlike apes to the lower forms, the reactions become progressively weaker, until the *Lemuroidea* (half-apes) are reached, when only a slight reaction occurs—indicating slight blood relationship.

In Austria and Germany, the "precipitation method" is employed by the police in the detection of criminals. For example, a suspected person is brought before a magistrate and charged with murder. On his sleeve blood-stains are discovered. "Where did these come from?" inquires the magistrate. "I was killing a chicken," replies the suspect. Now comes the blood test. The blood stains are soaked in a very weak solution of common salt, and, if necessary, the blood solution is filtered until it is quite limpid and clear. Into this blood solution a few drops of the "anti-human" serum are conveyed; and if the stains are of human blood, a white percipitate is thrown down; but not if the stains are of the blood of a fowl—or of any animal except man or an anthropoid ape.

Many a murderer has been detected by this simple method.

Anti-bovine serum, or any other, may be produced in the same way. Thus physiological tests have confirmed degrees of relationship already established between animals by other researches of anatomists and palaeontologists, showing that the close anatomical resemblance between the four higher anthropoids and man really means a *blood* relationship.

These facts do not, however, imply that man is descended *from* one or the other of the existing man-like apes, or that the latter are evolving toward the human estate. Man is no more descended from the gorilla or orang than those apes are descended from the chimpanzee or gibbon. Man and the anthropoid apes are branches of the tree of life, and if we trace these branches from their tips back to the common trunk, we find there a common ancestor of both apes and man; and, to go still farther back in time—millions of years ago—we should eventually find the common ancestor of all mammals—the first warm-blooded quadruped that suckled its young.

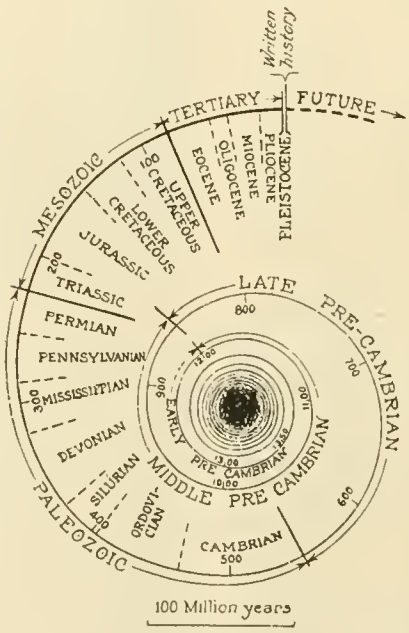
How Long Ago?

By EDSON S. BASTIN

GEOLOGY has made a notable contribution to an intelligent philosophy of life by giving us at least a rough idea of the amount of time involved in the great pageant of life-development. In geologic, as in human history we need to see events in their proper time perspective to understand fully their meaning. Having placed the varied forms of the past in their proper positions in the great procession of evolving life, how shall we know whether the procession moved rapidly or slowly? The question is so difficult that it may never be completely answered, but enough has been learned to show that profoundly long periods of time are involved.

How does the geologist solve a problem of this sort? There is no mystery in his methods. One of his simple guiding principles is that processes going on in the earth's surface today went on also in the past—the present is the key to the past. In the shallow waters of the shores of Lake Michigan he sees the sand marked by a series of little ridges and if he watches he can see that these are formed by the drag of the waves on the lake bottom. He calls them ripple-marks.

His next excursion is to a quarry where hard rock, sandstone, is being quarried. The quarryman with his hammer splits a piece off a solid, flat ledge and there on its surface are ridges or ripple marks precisely like those he saw forming on the lake bottom. The natural and reasonable conclusion is that what is now sandstone was once sand shifted by the waves in the shallows of a lake or the ocean.



Graph illustrating geologic time and the evolution of earth's history. From David White, U. S. Geological Survey.

On another excursion to a new locality, the geologist finds sandstone beds showing the same sort of markings, but this time the ripple marked surfaces are standing vertical instead of lying flat. From this he concludes, not only that lake or ocean waters once stood where now is a sandstone quarry, but also that since then the sandstones have been tilted by earth movements from their original flat-lying position until now they stand vertical.

Similarly in Italy the geologist sees rocks of peculiar kinds forming today from cooling lavas of Vesuvius. When later, on our New England coast, he finds rocks of almost identical sorts he concludes that once volcanoes were active there altho they have long since ceased to belch forth molten lavas and their once mountainous forms have been worn down to low-lying plains.

It is by methods equally logical, if not quite as simple, that he learns something of the age of the earth. At the mouths of rivers and along shores he sees rocks in process of formation as muds and clays and sands. By careful watching he can learn how long it takes to accumulate an inch or a foot of such sediments. In other places they may be accumulating faster or slower, and some sorts of sediments form much more slowly than others, but by many observations scattered over the earth he can arrive at some rough average of the time necessary to accumulate a foot of these sediments. On the average it appears to take something like 900 years for a foot of sediment to be laid down.

Now if we multiply this period of time by the total number of feet of sediments that have accumulated in the past to form our great series of sedimentary rocks—70 miles in thickness in all—we arrive at a figure of around three hundred million years as the time necessary for them to accumulate. Crude as is this method and fraught with many uncertainties, it yet gives us some rough notion of the immense periods of time involved in the history of the earth.

Another method of calculating geologic time is based on the amount of common salt in the oceans. Water falling as rain on the earth's surface dissolves salts of various kinds as it flows off over the surface or underground, eventually to join the brimming river and travel to the sea. Some of the salts are deposited when they reach the ocean, but most of the common salt remains dissolved in the ocean waters. It is possible to calculate roughly, from the known size of the oceans, how much common salt they contain. It is also possible to calculate roughly how much common salt is being carried to the ocean in a year by the rivers of the world. Dividing the first figure by the second gives us a figure of around 100 million years for the age of the ocean. Obviously this method of calculation has many grave uncertainties and is valuable only in giving a rough conception of the general order of magnitude of the periods of time involved in geologic history.

The newest method of measuring the age of the earth is by far the most ingenious and probably the most reliable. There are substances that are continually disintegrating by giving off what are commonly called rays or emanations. The radium or thorium salts used for the luminous figures on the dials of clocks and watches are substances of this sort. While many of the substances that thus disintegrate spontaneously are produced only in the laboratory, some are minerals occurring naturally in the rocks. Now the significant point is that the *rate* at which such minerals disintegrate is nearly constant and can be measured in the chemical laboratory in terms of our ordinary time units of hours and years. Furthermore when such minerals disintegrate, certain of the products of disintegration remain in their entirety associated with the original mineral. If then we determine by analyzing their proportions in

the mineral what degree of disintegration it has undergone we can get a measure of the number of years that have elapsed since the mineral was first formed in its fresh state in the rocks.

Thus measuring the age of the earth in the chemical laboratory, we arrive at even more astonishing estimates of geologic time than were obtained by the older methods. If, using these newer methods, we hastily run the gamut of some of the major events of geologic history, dating them as we go, we find that the oldest rocks now exposed on the earth's surface were formed something like 1500 million years ago.

The first clearly recognizable remains of living forms preserved in the rocks—forms that lived in the sea—appeared at least 600 million years ago, although less direct evidences show that life itself appeared much earlier than this.

Something like 400 million years ago living forms first crawled out of the sea to inhabit the land—these first known land animals being scorpions. Footprints in rocks formed perhaps 350 million years ago are our first record of backboned animals living on the land at least part of the time.

About 40 million years ago appeared the lemurs, the first representatives of the great group of primates to which man belongs. And perhaps half a million years ago appeared in far off Java the first of the forms that can properly be called human.

If, to grasp more readily the relative values of these intervals of time, we should reckon as one day of 24 hours the time since clearly recognizable forms of life appeared on the earth, then man has existed only for the last minute of that day and the entire sweep of English History since the Ancient Britons first crossed the channel from the continent has occupied only the last second of that day.

How reliable is this geologic clock based on the dissociation of radioactive elements? Can we be absolutely sure that their disintegration has continued at exactly the same invariable rates throughout all the vast stretches of time? Possibly not; but this at least is true, the *relative* ages of various rocks as determined by this method agrees with their relative ages as determined by their geologic relations to each other—and this fact gives us confidence in the method. At least our clock never strikes ten until it has struck nine and does not strike nine until after it has struck eight.

Making due allowance for all the uncertainties of such methods of estimating geologic time, it is at least clear that the physical conditions on the earth's surface began to be hospitable for life at periods almost inconceivably long ago and that throughout all subsequent time they have never varied sufficiently to result in its extinction, for the chain of life development has been continuous. There seems to be no reason to expect that our physical surroundings will cease to be hospitable to life for countless ages to come. In the relatively brief space of man's existence on the earth—the last minute in our geologic day—he has harnessed the inanimate forces of nature and has brought all other forms of animal life except a few disease germs into subjection to him; he has greatly extended his term of life by his partial conquest of disease and by better protection from the elements; and he has developed powers and qualities of mind and spirit not remotely approached by other living creatures.

With a clear field ahead, what magnificant progress may be his if he accepts his responsibility for continued progress. His main enemies are now within himself—and he may well beware lest in the increased ease of living he loses the vigor and the homely virtues that are necessary for the progress of the race upward and onward.

Ripple-marked Potsdam sandstone with trilobite trails, Port Henry, N. Y. (In New York State Museum).

ABORIGINES of Stone Age culture are reported to have been found by W. Lloyd Warner, anthropologist, on small islands north of Australia. He said that they have no religion and no money, but an elaborate social organization, marked rules of conduct and obedient children. They are polygamous and the women do most of the work. Their only weapons are stone-headed spears.

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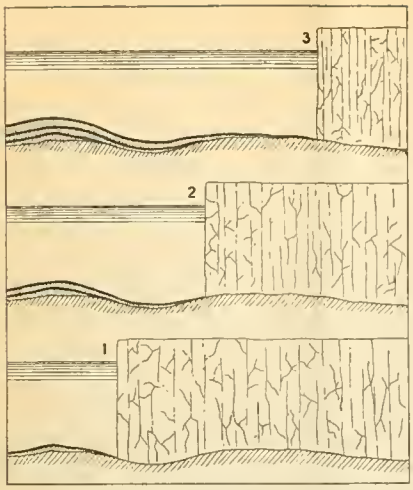


How annual clay layers were deposited in fresh water off the receding ice front during three successive years.—From Antevs.

THE GREAT CLAY

THERE still live many who take seriously the chronology drawn about 1650 by James Usher, Archbishop of Armagh, who set the date of Creation in the year 4004 B. C. by the simple method of adding Adam's 930 years to Enoch's 365 years to Methuselah's 969 years, etc. Dr. John Lightfoot, Vice-Chancellor of Cambridge University, promptly "improved" on this dating by specifying that the Creation occurred on October 23rd, at nine o'clock in the morning. But later scholars, of equal "authority", have placed the date variously at 4710 B. C. and 5872 B. C., the resulting debate lasting (in certain circles) to this very day. (See page 19.)

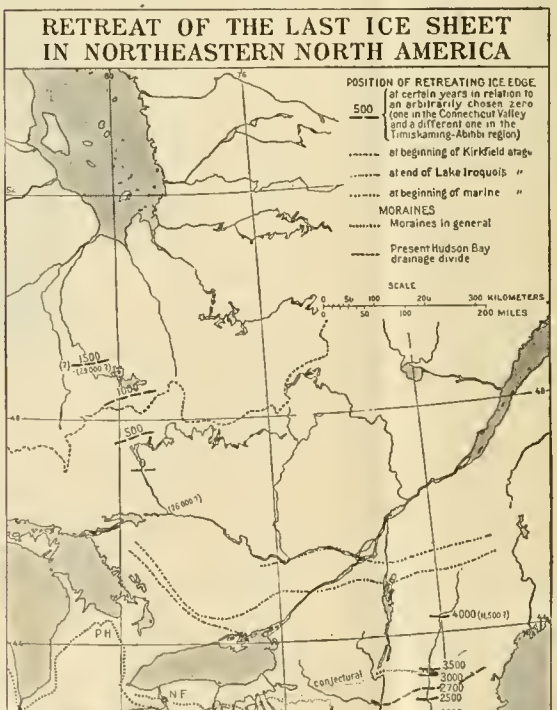
But meanwhile, for half a century, the geologists have been confidently talking of millions and lately of billions of years since the Earth was born, and have developed dependable methods for closely estimating the ages of our oldest rocks. But especially conclusive is a method now used by the glacial geologists to date (almost to the year in some cases) the progressive recession of the great ice sheets from northern Europe and North America, which dates take us back definitely some 13,500 years, long before the orthodox dates of Creation.

The method, originally suggested a century ago by an American geologist, Alfred Smith, and first applied about 50 years ago by Baron Gerard DeGeer of Sweden to working out a post-glacial chronology, consisted in counting the number of layers in clay deposits, each layer representing a year, much as we measure the age of a tree by counting its annual growth rings.

Several years ago, in a rear storeroom of the American Museum of Natural History, I was privileged to examine a collection of banded clays carefully preserved in long metal trays and soaked with glycerine to keep them from drying and shrinking. From them, Dr. Chester A. Reeds and other geologists were reconstructing the history of the New Jersey, New York and New England areas since the close of the Great Ice Age, long before the coming of the white man. They already had a complete year by year record covering thousands of years, but not definitely connected with modern dates.

They had examined hundreds of clay pits (often already nicely dug out for brick yards) along the Passaic, Hackensack, Hudson, Connecticut and Merrimac rivers. They either measured the series of clay layers by marking them on long, strong strips of paper (see center illustration), or they took samples of the clay itself by pressing a long, narrow metal tray vertically against the smoothed clay wall and then cutting the enclosed clay loose from the mass. This latter method was often necessary when the layers were too alike in thickness, but showed distinctive differences in color or texture by which they could be identified in several locations. In the laboratory, all the measures were charted for ready comparison and the work of counting for actual dating was done.

At that time, one of the group, Dr. Ernst Antevs, was away up in the wilds of Canada, laboriously gathering more samples and measuring clay layers in an attempt to extend the series of years and fix definite dates for all the various stages of melting and



The letters indicate moraines: T.M.—terminal moraine. R.—Ronkonkomon, H.H.—Harbor Hill. M.—Mississinawa. D.—Defiance. A.—Alden. N.F.—Niagara Falls. P.H.—Port Huron.—From Antevs.

Annual clay layers and
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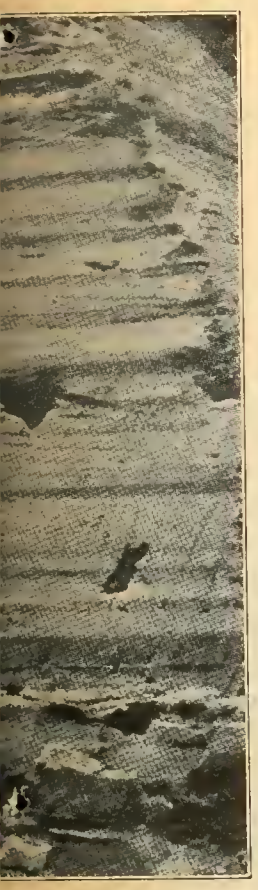
CALENDAR

By ALLAN BROMS



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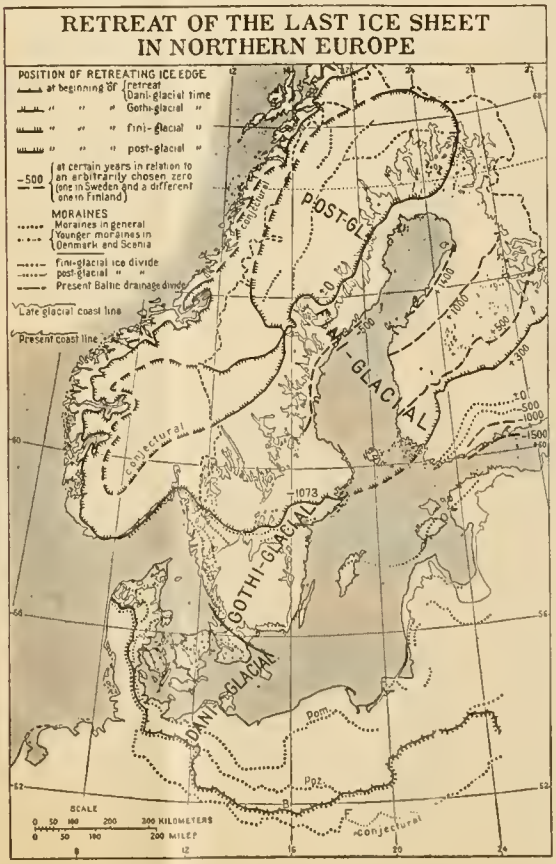
Fortunately, the layers are not all alike from year to year. Long, hot summers resulted in thick gravel layers, while shifts in outflow caused new kinds and colors of outwash deposits. Such distinctive layers can often be identified over wide areas in several clay deposits. By going from one to another and making careful comparisons, a complete series may be worked out from the overlapping local records to make a continuous calendar for thousands of years. In northern Sweden, fortunately, it was possible to trace the series to the very fronts of existing snow-fields (where just such clay layers are now being laid down each year), so connected definitely with our times.

Obviously, no layer could be formed at any point until the ice had melted away and uncovered it. As the ice edge receded, each succeeding annual layer would extend a bit farther north, overlapping somewhat like the shingles on a roof. The margin of the layer (where it touches bedrock at any date), therefore marks the edge of the ice-sheet at that date. By this method, the stages of retreat of the Baltic Ice Sheet have been carefully dated as shown on the small map. The entire record, though it does not go back to the very beginning of the glacial recession,



The principal moraines are indicated as follows: F.—Flaming. B.—Brandenburg. Poz.—Poznan. Pom.—Pommerania.—From Antevs.

The dates of the principal stages of retreat of the Baltic Ice Sheet.

does go back some 13,500 years, long before the Fundamentalists' year of Creation.

A long, oscillating halt of the ice front in the Danish Islands and southern Sweden ended some 13,500 years ago. By this time or soon after, our own ice sheet was just retiring from the Great Lakes region. A notion of the succeeding stages in both areas can be gained from the two large maps that show what we have learned from the Great Clay Calendars. The relative completeness of the Baltic Calendar is apparent. The American Calendar has serveral gaps, which we must fill as best we may from other calendar data, such as the gorge-cutting by Niagara Falls, the changes in the Great Lakes, and by tracing across the country the long moraines of dumped earth and rock which piled up along the edge of the melting ice sheet at its greatest extension or where it halted or readvanced slightly in its general northward retreat. Such moraines are indicated by dotted lines on the maps and do serve to mark contemporaneous locations of the ice front, since they were deposited at much the same time. The year figures given on the geologists' working maps are not our own calendar dates, but are relative to arbitrary base locations of the ice front (for no actual dates are ever known at the outset). But on the American map, figures have been guessed at for the number of years after the beginning of glacial retreat. Both the southern and northern ends of this record are missing, but good guesses seem to be that this beginning occurred about 40,000 years ago, certainly more than 30,000, probably less than 50,000. In this brief period (brief geologically) the great ice sheets have shrunk to some mountain glaciers in the Alps and Scandinavian mountains and to a more considerable ice cap over Greenland. But even the Greenland ice cap, thick and immense though it be, is a mere remnant of the miles-thick ice sheet which once covered some four million square miles of our continent.

References: Ernst Antevs, "Recession of Last Ice Sheet in New England" (1922); "The Last Glaciation" (1928).

How Evolution Works

By H. J. MULLER

V. X-RAYS CAUSE MUTATIONS

The opening chapters in our last issue considered the various theories of the cause of evolution, reviewed the principles of genetics, proved the randomness of mutations and traced their origin to the "newly found world of the little," the genes. We'll send this first part to any new subscriber upon request.

IF this general conception of mutation is valid we must regard it as being merely a kind of placing of the problem; we should not yet know just which were ordinarily the critical processes concerned, still less the exact steps involved. The conception carries with it, however, suggestions for further experimental investigation. For among the agents of an ultramicrospically random character, that can strike willy nilly through living things causing drastic atomic changes here and passing everything by unaltered there—not a ten thousandth of a millimeter away, there stand preeminently the X- or Y- (gamma) ray and its accomplice, the speeding electron. There is nothing in protoplasm which can effectually stop the passage of X-rays or the related waves of shorter wave-length—gamma and cosmic rays. For the most part, in a cell, the rays will pass through but at isolated, unpredictable spots, depending upon unknown "chance" details of energy-configurations, a definite portion, a "quantum," of the rays will be held up, and part of the energy thus absorbed will issue forth in a hurtling electron, shot out of the atom that stood in the way of the radiation. The atom will be changed thereby, and hence the molecule in which it lies may undergo a change in its chemical composition. But for every atom thus directly changed there are thousands of other atoms changed indirectly. For the electron, shot out like a bullet (except far faster), tears its path through thousands of atoms that happen to lie in its way, leaving in its wake a trail of havoc before it is finally stopped. In this process, many of the atoms through which the electron tears have one or more of their own electrons torn out or dislodged from their proper places; this change in the structure of the atoms often causes them to undergo new chemical unions or disunions that in turn alter the composition of the molecules in which the atoms lay. If a gene is a molecule, then, with properties depending upon its chemical composition, it can be shot and altered by the electrons resulting from the absorption of X-rays or rays of shorter wave-length. The only question would be, can enough mutations be caused in this way to be detectable by our present methods, with doses of rays small enough not to kill or sterilize the treated organism?

With these points in mind, the author undertook in the fall of 1926 a series of experiments designed to test the question at issue. The fruit-fly, *Drosophila*, was used, since it is so easily and rapidly bred in large numbers and since it rendered possible the employment of special genetic technique for the finding of mutations, that had been elaborated in the course of my previous work on linkage and mutation in this organism.

It would take us too far afield here to examine this technique in detail. Stocks of flies had been made up containing in given combinations certain genes with conspicuous effects which would serve to notify the investigator that the chromosome under consideration was present. On making given crosses of these stocks with other stocks various combinations of characteristics would be expected in the first and following generations. If flies with some particular expected combination were, however, absent from a given culture, it would mean that a mutation had occurred that had given rise to a lethal gene—one that had killed the flies containing it before they had a chance to hatch. By noting which combinations were missing it could be deduced which chromosome of the fly the lethal was in, and at what place in the chromosome it lay. On the other hand, mutant genes having visible instead of lethal effects would be detectable through the appearance of the visible variations, and these too could be traced to their chromosome position through studies of the nature and frequency of the combinations in which they appeared. Mutant genes that were recessive to the normal type, however, and most mutations are recessive, would not have a chance to be seen or found until the second or third generation of offspring, subsequent to their origination. The reason why recessive mutations are not evident at once has been explained previously.

In these experiments the adult flies—in some cases the males, in other cases the females—were placed in gelatin capsules and subjected to doses of X-rays so strong as to produce partial sterility, though the other functions of the flies are not noticeably disturbed by a dose several times stronger than used here. The treated flies were then bred to untreated mates, and at the same time numerous control matings of the same genetic type were carried on for comparison, consisting of untreated males crossed by untreated females. Thousands of cultures were used in this and subsequent experiments, in order, if possible, to settle the matter beyond any doubt.

Startling Results

The results in these experiments were startling and unequivocal. To the toiling pilgrim after plodding through the long and weary deserts of changelessness, here indeed was the Promised Land of Mutations. All types of mutations, large and small, ugly and beautiful, burst upon the gaze. Flies with bulging eyes or with flat or dented eyes; flies with white, purple, yellow or brown eyes or no eyes at all; flies with curly hair, with ruffled hair, with parted hair, with fine and with coarse hair, and bald flies; flies with swollen antennae, or extra antennae, or legs in place of antennae; flies with broad wings, with narrow wings, with upturned wings, with downturned wings, with outstretched wings, with truncated wings, with split wings, with spotted wings, with bloated wings and with virtually no wings at all. Big flies and little ones, dark ones and light ones, active and sluggish ones, fertile and sterile ones, long-lived and short-lived ones. Flies that preferred to stay on the ground, flies that did not care about the light, flies with a mixture of sex characters, flies that were especially sensitive to warm weather. They were a motley throng. What had hap-

pened? The roots of life—the genes—had indeed been struck, and had yielded.

It must not be supposed that all the above types appeared congregated together in one family. The vast majority of the offspring that hatched still appeared quite normal, and it was only by raking through our thousands of cultures that all these types were found. But what a difference from the normal frequency of mutation, which is so painfully low! By checking up with the small numbers of mutants found in the numerous untreated or control cultures, which were bred in parallel, it was found that the heaviest treatment had *increased the frequency of mutation about* 150 *times—that is, an increase* of 15,000 *per cent.*

VI. SIMILARITY OF THE X-RAY TO THE NATURAL MUTATIONS

Yet these mutations were obviously of the same general nature as the spontaneous mutations that occur without X-ray treatment. This was shown by the fact that in many cases changes had been produced which were undoubtedly identical with spontaneous variations which had been found in the previous history of the *Drosophila* work; the effects in these cases appeared identical in every particular, and the method of inheritance, the position of the gene concerned in the chromosome, was found to be the same.

The new types of mutations, like the old, conformed in their general expression and mode of inheritance to certain general principles which I have previously observed to hold in the case of the mutations occurring in untreated material. One of these principles was that the great majority of the mutations—of X-ray as well as of natural origin—are recessive to the normal type, despite the presence of a rather small minority of dominants. Thus the technique of breeding out through a number of generations in order to find the mutations was found to be justified. And it may be remarked here that if human beings are affected by X-rays in the same way as flies, we can not expect to find much evidence of a mutational effect of X-rays on them from data derived only from the first, or even the first, second and third human generations, and such a negative result will therefore by no means indicate a lack of significant genetic effect.

The second principle observed was that the X-ray mutations, like the natural ones, included both inconspicuous as well as conspicuous changes, changes of slight or almost imperceptible degree as well as striking changes of structure or quality, and changes that registered their effect, so far as could be determined, only in slight lowerings of the general vitality, as well as those that were more graphically describable. If anything, the more easily overlooked effects were the more frequent.

A third principle noted was that most of the X-ray mutations were in some way detrimental to the animal in living its life—they were steps in the wrong directions in the struggle for existence. This finding has already been discussed in the case of the natural mutations, and it has been explained that this is just what is to be expected, on the whole, of changes that occur at random, accidentally, "by chance"—I care not what term you wish to use to describe the idea that they occur without reference to their consequences, unadaptively, and hence are more likely to be "wrong" than "right" changes, just because there are more wrong roads than right roads to follow, and because, as is well known, the right road is apt to be the narrower. In the case of the X-ray mutations it is easily seen that, if the change occurs as I have pictured it, it *must* occur accidentally, without reference to the possible advantage or disadvantage it would confer, since the shooting electrons let loose by the X-rays are coursing helter-skelter through the cell, quite blindly, and are just as apt to hit one gene as another, to strike it either on its left or its right side, through its heart or its appendix, so to speak, and so will cause one change or another indiscriminately. We have in the X-ray mutations, then, a group of variations which seem *necessarily* to be random, and hence would necessarily be mostly detrimental. In view of this, it is interesting to compare with them in this respect the natural mutations, and to note that, so far as our evidence goes, the natural mutations have, on the average, every bit as much tendency to be detrimental as the X-ray mutations have. The obvious conclusion is that the natural mutations too must be random changes, in the same sense that the X-ray mutations are.

Most Mutations Kill

As in the studies on natural mutations, so too among our artificial ones, the great majority were lethal—they killed the fly before it ever hatched, except where there was a normal gene from the other parent to dominate over the lethal and save the fly's life, so that it could be bred and the method of transmission of the lethal studied. The changes in wings, eyes, etc., previously mentioned were only the exceptional visible changes, culled from out of a great mass of lethals. Thus, although the great majority of the descendants of X-rayed flies that lived *looked* normal, many of them carried, hidden by the dominant normal gene, a recessive lethal gene. And if we count up all these lethals we find that the majority of the offspring of heavily X-rayed flies are not really normal in their genes after all, for something over 50 per cent. of them contain some kind of lethal mutation that will not work its destruction until a still later generation. This too deserves being considered in its bearing on X-ray effects in the case of human beings. Now previous studies of Altenburg and myself on natural mutations have shown that among them too, although the total frequency of mutations is so much smaller, nevertheless the number of lethals is just as large, *relatively* to the number of other, visible mutations which occur naturally, as it is among the X-ray mutations. As the lethals differ from the others, after all, merely in being more detrimental, this result simply means that natural mutations are just apt to be very detrimental, *i.e.*, lethal, as are X-ray mutations, thus confirming what I have called the "accidental" character of the natural mutations.

The descendants of the X-rayed flies have been bred through many subsequent generations. It is found that, where a gene was not caused to mutate in the first place, it will not show a subsequent tendency to mutate, without further treatment, *i.e.*, there is no perceptible after-effect on the genes that escaped an immediate hit. On the other hand, those genes that were hit and mutated now breed true to their new type, which in the great majority of cases gives evidence of being as stable as the original type was before treatment. We now have in the laboratory various mutant races of flies, derived from our earlier X-ray experiments, which have passed through something like fifty or more generations since the time the mutation took

place, and there has been no sign in them of any tendency to revert back to the originally normal condition. They have their own, new norm; they are real, new variants. The new forms are permanent, in so far as the word permanent may be applied legitimately to living things. And when crossed to other forms, the new differences obey the same laws of Mendelian and chromosomal inheritance as do the gene-differences existing between natural varieties.

VII. THE NATURE AND SIGNIFICANCE OF THE GENETIC EFFECT OF RADIATION

It might perhaps be contended in some quarters that while the artificial mutations may be similar in some respects to natural ones, and even identical with some natural ones, yet they may not be similar to those particular natural mutations which may be termed "progressive:" the mutant genes resulting from which survive, multiply and thus become a part of the heritage of an evolving species. Such claimants would hold that the X-ray action is necessarily destructive, causing only loss and injury, and that thus it can work *only* harm, or at least can cause no indefinite amount of progress in organization. Such a contention would rest upon a misconception of the action of the X-ray, for it can be shown that the speeding electron is capable of imparting energy to other atoms through which it goes, and that the resulting chemical changes may be of a synthetic character as well as otherwise.

It is evident, as my wife has suggested, that if the change induced by X-ray from, say, a gene designated as large A, to a mutant gene of different composition, designated as small a, has really involved a destructive process or a loss, then the opposite change, from small a to large A, must, conversely, involve a constructive process or a gain. With this question in mind, Professor J. T. Patterson and I have been engaged in some extensive irradation experiments involving particular characters. The character which we have used most is the recessive mutant character termed "forked bristles" (f), as compared with the dominant normal straight bristles (F). The evidence is now positive and convincing that the X-rays not only induce the mutation of straight bristles to the recessive forked, but also the precisely opposite type of change: namely, forked bristles to the dominant straight, and abundant controls have shown that it is really the X-rays which are the inducing agent. Since giving this lecture, the author has received several very important articles by N. W. Timofeëf-Ressovsky, describing numerous cases of the production of mutations in opposite directions by means of X-rays. Various different gene-loci were involved, and in the case of one locus (that of white eye) the mutations of, and to, various different allelomorphs, were observed. The mutations arising as a result of X-raying are, therefore, not merely destructive changes, not merely losses. If some are losses, others, then, are gains. Doubtless, as in the case of most chemical reactions, most mutations too are changes involving substitutions and rearrangements, not mere losses or gains.

Not Mere Curiosities

It should be mentioned that, in addition to the changes in individual genes which X-rays bring about, they also cause—with considerable frequency, as Altenburg and I have shown—breakages of entire chromosomes or strings of genes, accompanied by reattachments of the broken-off fragments to different chromosomes or to the chromosome-remainder from which they were broken, at a different point from before. The rearrangements of genes thus resulting can be analyzed by breeding tests, and at the same time checked up by studies of the chromosomes as seen through the microscope—an undertaking which Dr. Painter and I have been cooperatively engaged upon during the past two years. There is evidence that such rearrangements of chromosome parts, as well as mutations in individual genes, have occurred repeatedly in natural evolution.

The question may now be raised: to what extent can all these results be regarded as mere curiosities: effects confined to the mature sperm-cells of the fruit-fly, and of little significance elsewhere? In this connection, it may first be pointed out that my results in producing gene mutations in the fruit-fly were immediately confirmed by Weinstein, working at Columbia University, later by others (Hanson, Patterson, Harris, Oliver) at this laboratory, and more recently by Serebrovsky and his colleagues in Russia and by Dr. and Mrs. Timofeëf-Ressovsky in Berlin. In my own work, the treatments were not confined to sperm-cells, but were also applied to the female, and it was found that both the mature eggs and the immature female germ-cells (oogonia) were susceptible to the mutation effect. Harris has recently extended the finding to the immature germ-cells of the adult male. Paterson has found the early germ-cells of both male and female larvae are likewise susceptible and also the larval somatic cells. The latter finding, which has recently been announced also by Timofeëf-Ressovsky, opens up a whole realm of interesting possibilities in the production of mutant areas of the adult body, derived from cells of the treated embryo—such effects as might result, for instance, in an individual with eyes of different colors, or with parts of the same eye different. Casteel has been making an anatomical analysis of these latter effects through microscopic sections of the eye. The production of mutations by X-rays is thus a general effect for *Drosophila*, producible in all kinds of cells in that organism. What, now, of the generality of the effect on other organisms?

Results Amply Confirmed

I need not, perhaps, remind the general reader of the fact that all the principles of heredity so far discovered in the fruit-fly—the favorite experimental object of many modern geneticists—have proved applicable to animals and plants in general. It is more to the point to mention that investigators elsewhere, working on other organisms, have now reported results of the same kind as those now in question. Thus, Stadler, at the University of Missouri, was independently attempting to induce gene-mutations in barley and corn by means of X-rays and radium at the same time that I was doing my first experiments along these lines on flies, and he has found indubitable evidence of the production of gene-mutations in monocotyledonous plants by both these means. Following my work on flies, Whiting has obtained positive results by the use of X-rays on wasps. Blakeslee, Buchholtz and the others of this group have a mass of interesting mutation results from X-rays and radium applied to the Jimsonweed, Datura, that extend the findings concerning lethal as well as visible mutations to dicotyledonous plants. With these so widely separated bits of the living world sampled and all responding positively, it is a reckless critic who still would doubt the probable generality of the phenomenon.

Radium rays, like X-rays, produce mutations, because they too, being short-wave-length high-frequency electromagnetic waves of great energy content, release high-speed electrons, and the cosmic rays, which are still more extreme in these same respects, and so release electrons of still higher speed, must necessarily act likewise. For, as Hanson has shown in experiments with radium, the number of mutations produced depends simply on the number of electrons released and the speed and distance they travel (*i.e.*, on the total energy of ionization) regardless of the source of the electrons. Oliver, too, in experiments with X-rays in our laboratory, has obtained evidence that the number of mutations produced is directly proportional to the dosage of radiation used, and Stadler's work points in the same direction. This being true, there being no evidence of a minimal or "threshold" dosage, we are forced to conclude that the minute amounts of natural radiation present almost everywhere in nature—some of it of terrestrial origin, derived from the radium and other radioactive substances in earth, water and air, and a smaller part of it of cosmic origin, apparently derived from the diffuse and distant factories of matter—all this natural radiation *must* be producing some mutations in the living things on the earth. These mutations must be very scattered and very infrequent in proportion to the total non-mutated population, just because the amount of natural short-wave-length radiation is very small at any one place, but, considering the extent of the earth and the multiplicity of living things, the total number of mutations so produced per year must be very considerable. It can, therefore, scarcely be denied that in this factor we have found at least *one* of the natural causes of mutation, and hence of evolution.

To Find Other Factors

And yet, despite the fact that radioactive processes are capable of causing the changes that lie at the basis of evolution, and do undoubtedly cause some of them, it is probable that they themselves are responsible for only a minute fraction of the mutations that occur in nature, and that their value, for the theory of evolution, lies rather in their illustrating the general type of the phenomena to which mutations belong, and in providing us with all kinds of mutations in abundance for purposes of analysis. X-ray, cosmic rays, and the radiation from radioactive substances are not themselves the cause of the vast majority of natural mutations, if the calculations which L. M. Mott-Smith and I have recently made are correct, for these calculations indicate that the amount of such radiation in nature is far below what would be needed to produce the numbers of mutations which are observed to occur. There are probably, then, other factors, working in a similar way to X-rays, that are the actually operative causes.

The attempt to find these other factors is proceeding. The natural phenomena most closely related to the radiation which we know to be effective are rays of the ultraviolet region of the spectrum (of wave length too short to affect our eyes). Though preliminary tests conducted by Altenburg have not demonstrated an effect of such rays, it is too early to be certain of a conclusion here, for a mixture of wave-lengths was tried, none of which, however, were of the extremely short type, and it might still be true that some particular wave-lengths, especially the very short ones (more nearly like X-rays), would be found effective. It is to be recalled in this connection that Gurwitsh and other Russian investigators claim that rays of exactly this kind are produced in living matter—a kind of ultra-phosphorescence—stimulating cells to divide.

If the random motions of the atoms and molecules of the cell, striking against one another, are capable, when "favorable hits" occur, of causing mutations, as we have supposed the X-ray "hits" to do, then raising the temperature should cause a rise in the mutation frequency, just as it causes a rise in the rate of other chemical reactions. Experiments by Altenburg and myself indicate that it does so; this work requires large numbers and is now being repeated. On the other hand, more specific chemical influences have so far failed. Returning to the investigation of the possible effectiveness of poisons and other influences than X-rays, I have, during the past two years, tried out a number of drastic treatments, using a refined genetic technique similar to that in the X-ray experiments, which would have allowed of the detection of lethals and other mutations with far greater ease, and therefore in greater abundance, than in the inconclusive experiments of the past. Included among the treatments were heavy doses of manganese and of lead salts, which had been claimed by J. W. H. Harrison (on the basis of what appeared to me genetically unconvincing data) to produce visible mutations in butterflies. There was also included a repetition of the experiments reported by Morgan, who at one time suspected that he had been able to cause visible mutations in the germ-cells of red-eyed flies by injuring their eyes with a hot needle, an operation which was followed by a release of the optic pigment and its distribution throughout the body. But our trials of all these and of a number of other chemical agencies have given negative results, and it is becoming evident that a mere derangement of cell functionings does not ordinarily cause mutations.

Another method of studying the way in which mutations are produced is to investigate the possible effect of other conditions applied along with radiation. There is now evidence that some other conditions, internal and perhaps also external, accompanying an X-ray treatment, can affect the sensitivity of the cells to that treatment. Thus Stadler finds that the sprouting cells of seedlings have mutations produced in them in much greater abundance, by a given dose of X-rays, than do the dormant cells of seeds, though some mutations are produced in both. Yet in the case of flies both Hanson and Harris, working independently, find that the genes of growing immature male germ-cells are far less sensitive to the mutating effect of radium or X-rays than are the dormant genes in mature spermatozoa. I find that the genes in the spermatozoa of the adult male are also more sensitive than those in the germ-cells of the female, or than those in the germ-cells of the larval male. It is probable that part of these apparent differences are due to a relatively lower multiplication rate of most mutated immature germ-cells, as compared with the non-mutated ones. There seems to be even more difference in their sensitivity to the gene-rearranging effect of the rays than in their sensitivity to the transmuting effect on individual genes. The activity of metabolism, however, varied by starving, and by feeding and mating the female, had no perceptible influence in my experiments, and, as both Stadler and I have found independently on barley and flies respectively, extremes

Question Box

Answers by ALLAN BROMS, *unless otherwise credited*

NIAGARA VERSUS CHICAGO

Q. In your "Story of Niagara" you claim the Falls are cutting upstream towards Lake Erie. When it cuts way through, will it not lower the Great Lakes and leave all the lake cities, that are now quarreling with Chicago over its drainage canal, high and dry?—J. P. C.

A. Maybe, as far as lowering the outlet and therefore the surface of Lake Erie is concerned. This may cause a temporary waterfall or rapids in the Detroit River outlet of Lake Huron, but the stream would soon clear away the glacial moraine material which makes the barrier there. Lake Huron and Lake Michigan, would then also be lowered.

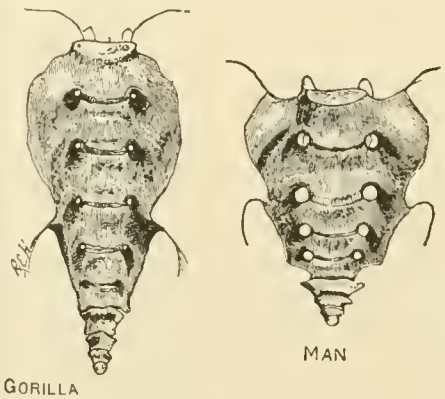
The problem is complicated by a tilting of the earth-crust now going on in the Great Lakes area. The northeastern portion is rising, a movement that has been in progress ever since the glacial ice sheet retired from this region, so relieving the pressure on the crust, most recently of course in the northeast. The north shore of Lake Ontario, for instance, is rising faster than the south shore, which is being slowly submerged.

The Niagara lakes outlet is thus slowly rising in a sort of nip and tuck race with its erosional deepening. If the rising is faster than the deepening, the level of the Great Lakes above it will also rise, perhaps enough to flood Chicago (solving the problem of its drainage canal) and drain southwest to the Illinois and Mississippi rivers as they did once before when the banking ice sheet to the northeast prevented eastward drainage. The race, therefore, is really between the Niagara and Chicago outlets, with the ultimate result uncertain. But whatever the fate of the lake cities, let it not effect your sense of real-estate values, for it is all far in the future and some human channel-deepening at Niagara or a few well placed stone embankments along the lake fronts could easily thwart this leisurely upheaval by Nature.

THE "MISSING LINK" AGAIN

Q. I have heard a lot about the "missing link." What is it?—A. K. S.

A. Objectors to evolution have persistently argued that there is some "missing link" between man and his animal ancestors. The term has been loosely and variously used to mean either some



GORILLA MAN

intermediate ape-man supposed to be lacking, or the presence or absence of some distinctive organ marking man apart from the apes.

Before 1892, when the fossil remains of the Java ape-man, Pithecanthropus erectus, were found, the first objection had some point. But now we have not only this half-human fossil, but a whole connecting series, those above the Java type, such as the Peiping, Piltdown, Heidelberg, Neanderthal and Cro-Magnon men, and below it the manlike ape of Taungs. Consequently, only the most ignorant now talk of such a missing link.

But so-called "missing links" of the other sort pop up from time to time. Typical is the claim that "man has no tail," it being assumed that apes have tails, which happens to be untrue. All that apes have are some bony remnants of a tail, but if that gives them a tail, then man has it, too, for he has similar remnants. Also many attempts have been made to find something distinctive about the human brain. Back in 1863, Huxley had to prove that the "hippocampus minor of the posterior cornu of the lateral ventricle," a little hump within the inner cavity of the human brain, also existed in the apes, that being the "missing link" according to Fundamentalist objectors of his day. More recently, the ape has been credited with an extra fold in the back of his brain, called by the Germans the "Affenspalte" (ape-fissure) and said to be lacking in man, which made it at once in some way important. But G. Elliot Smith showed that it does occur in man, but usually only on the left side (associated with right-handedness) and that the brain casts of several early fossil men also show it, in the case of the Java ape-man on the right side, indicating that he was left-handed. The human brain really is somewhat more finely wrinkled than the ape's, but this we would expect, the significant thing being that the general pattern of the brain folds is quite the same.

The only real gap in man's whole pedigree is that between the first fishes and their immediate ancestors who lacked a backbone. But even here we have good theories, the only trouble being that we have two of them. However, the "missing link" objectors will find no comfort here, for that gap is too far back in our ancestry to save us from our obnoxiously close kinship with those ugly apes. The evidence of that kinship is much too overwhelming when we consider all we have in common in bodily structures, chemical functioning, embryonic development and now those most decisive blood tests. Besides, the "missing link" is actually not missing.

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of heat or cold applied in treatment have little or no effect.

Thus the study of the physiology of mutation-production is opening up, though as yet in a very empirical stage. And meanwhile, X-rays and their relatives remain the only prime cause of mutations yet known.

Since, now, mutations in general bear all the earmarks of the X-ray mutations, then, even though most of them have not actually been produced by radiation, it seems legitimate to use the readily obtainable X-ray (radium, etc.) mutations as the handle by which to study their nature. These X-ray mutations are certainly accidental, being produced by ultra-microscopic events, not individually controllable, that take place without reference to the outcome or the advantage for the organism. The natural mutations—the majority of which can be reinvoked by X-rays—are on the average equally as detrimental, and of the same nature, so far as their effects are concerned, as the X-ray mutations. Can we then escape the conclusion that they are accidental in the same sense, and that specific mutations are therefore not dictated by any "adaptive reactions" or other specific responses of the organism to climate or to any other features of its mode of life?

(To be concluded)

The Amateur Scientist

A Monthly feature *conducted by* Allan Broms

NATURE'S HUMBLE PLOWMEN

According to an official report, one great damage done by the Mississippi flood was drowning the earthworms throughout the inundated area. This does not indicate a wave of official compassion for earthworm feelings, nor even concern over wholesale loss of good fishing bait, but merely that earthworms have come to be recognized as an economic necessity in that they act as Nature's lowly plowmen who loosen, pulverize, moisten and otherwise transform our soils to greater fertility.

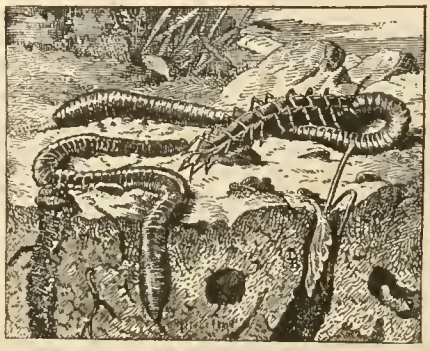
Charles Darwin was first in realizing their soil-forming function and the vastness of their gardening operations. His studies extended over more than forty years, finally resulting in his book, "The Formation of Vegetable Mould Through the Action of Worms," published in 1881 shortly before his death and strangely enough, "best-seller" for his day.

The most patient experiment of this most patient experimenter was on earthworms, when he spread chalk over a field and then waited 29 years to dig and learn how deeply the layer had been buried. For his father-in-law, Josiah Wedgwood, had suggested that the sinking of stones into the soil might be due to the earthworms bringing earth to the surface in the form of their castings. Darwin's research proved this, that the worms, in their burrowings, ate earth for the organic matter it contained, then deposited the excrement castings on the surface.

He found an average of more than 50,000 earthworms to the acre in the tillable soil of England (in America they are fewer), that some 18 tons of soil per acre passed through their bodies yearly to cover the surface at the rate of an inch thickness every five years, in the course of ages thus burying even large rocks, monuments and ancient buildings. A recent German estimate in Kosmos gives this earthworm horde five or six times the importance of the human race, if we measure them by relative bodily volumes.

The earthworms are an ancient tribe, for we already find fossil burrows of their kindred in Cambrian rocks, some of them crescent in cross-section because their walls caved in when other worms pressed too close in their later burrowings. The tribe as a whole is distributed throughout the world, some attaining great size, such as those of Ceylon, a foot and a half long, and thick as a snake. But individual species (there being over a thousand) have more limited ranges.

The earthworm's habit of coming out of their flooded burrows after a rain has led the Germans to call them "rainworms." They also come out at night, returning at daybreak to escape their proverbial enemy, for the early bird catches the late worm. They can distinguish between light and darkness, but the tail is light-sensitive as well as the



head, and the worms are really blind, and also deaf. Sense of taste they have, for they are choosey of their food, and also a sense of touch that warns them of dangers that shake the ground. But they can do little to protect themselves beyond "Crawling into their holes and pulling the holes in after them" by plugging the openings with dirt. So they survive by sheer numbers and a very retiring disposition.

BOOKS

THE BIOLOGICAL BASIS OF HUMAN NATURE. By *H. S. Jennings*, W. W. Norton & Co., N. Y. $4.00

We are what heredity and environment make us. Heredity makes us deeply, environment remakes us superficially. Old fundamental biological truths these are, to which modern genetics has added vastly illuminating details on the mechanism, processes and limitations of both inheritance and variation. The whole subject is complex in its working details, yet not too complex in its basic laws. Jennings reveals his own clearness of thought by the relative simplicity of his presentation. He has seized upon the basic laws, presented much vital detail in developing them, and so succeeded in making a readable book that is soundly scientific. He makes the genetic approach, but reveals the interplay of mutually limiting factors, and judges the conflicting theories that the specialists of eugenics, behaviorism, etc., have overemphasized in their narrower viewpoints. In indicating the limitations of each factor, Jennings has given us a singularly whole view of what modern experimental biology tells of the making and remaking of our various human natures.

FLIGHTS FROM CHAOS, By *Harlow Shapley*. McGraw-Hill Book Co., N. Y. $2.50

THE MYSTERIOUS UNIVERSE. *Sir James Jeans*. MacMillian Co., N. Y. $2.25

Shapley and Jeans present a contrast which has become almost typical among physical scientists. Both write with delightful clearness in apt, popular phrases, and both have taken for their theme a survey of the Universe, with its unfolding mysteries. Both recognize that we find more mysteries as our vision of the Universe opens up, but what a contrast in attitude from mental chaos towards orderly scientific understanding as we awaken to the uniformities in the behavior of nature. Jeans sees but deeper mystery, finds faith in the involved mathematical metaphysics of the Einsteinian "relativists" and "multi-dimensionists," takes seriously the new sort of ether composed of permeating mathematical formulas, and somehow, among the dimensions, finds a Creator who is essentially mathematician. Shapley remains matter of fact, catalogs the material "systems" from atom to Universe, but fills his catalog with hints of coming knowledge, an unfolding vision of the vast galactic systems making up the incomprehensibly immense Universe, from time to time puts the upstart, Man, in his place, and altogether makes his catalog an absorbing delight. Best of all, he holds true to the well tested scientific method, indulges no metaphysical assumptions, mathematical or otherwise, but goes on ever confident that careful observation and experiment will yield their secrets of order in this, our Universe of seeming chaos. The contrast between these authors is one between the patient, plodding scientist who checks his brilliant imagination by laborious tests, and the impatient metaphysician who trusts all to the treacherous logic of the human mind.

MATERIALISM AND VITALISM IN BIOLOGY. By *Sir Peter Mitchell*. Clarendon Press, Oxford. $.70 in paper.
SPIRAZINES. By *Carl F. Krafft*. Published by Author. 2510 "Q" St., N. W., Washington, D. C. $.50 in cloth.

These two thin volumes discuss the nature of life from the mechanist standpoint, the one being a summary by an eminent British authority of our progress in understanding what life must be, with something of recent achievements. The other presents a new physico-chemical theory by an American specialist in organic chemistry. The first is popularly presented, the second technical. The one tells tales of organic compounds and seemingly living stuff made in the laboratory, while the other thrills as a plausible scientific guess at the inner working structure of the stuff of life.

Fundamentalist Follies

In this Monthly Feature EDWIN TENNEY BREWSTER *will refute all fundamentalist objections to evolution.*

THE ORDER OF CREATION

The words of my text are to be found almost anywhere in Fundamentalist writings—for example, in the *Bible Champion,* July, 1929, page 30.

"The fact of the matter is, the evolutionists first arranged the fossils according to the evolution theory, and now they turn about and claim that their arbitrarily classified series proves evolution —a clear case of arguing in a circle."

Interesting! Important! If true!

The fact of the matter really is that the entire scheme of geologic ages, the order, that is to say, in which fossil creatures occur in the rocks, was not discovered by "evolutionists" at all. The men who did it believed, one and all, in special creation. The main part of the job was all finished off and done with during the first half of the nineteenth century. Evolution does not appear on the scientific map until the second half.

Cuvier began it, and "Strata" Smith. But Cuvier was the great apostle of "Multiple Creation," whose opinion and arguments discredited the dawning evolutionism of his day. Smith was a Fundamentalist, who did not even agree with the evolutionary geology of Lyell and never heard of Darwin at all.

Then came Sedgwick, Buckland. Hugh Miller, and the rest of that group, with Agassiz. Not one man in the entire lot accepted evolution. Buckland and Miller died before *The Origin of Species* appeared; Sedgwick, though he had taught Darwin geology, wrote against him savagely and never accepted any of his views. Agassiz, "last of the Creationists" wrote against evolution almost the last thing he ever did.

Even Lyell, the outstanding advocate of evolutionary geology, did not accept the evolution of animals and plants until his epoch-making *Principles of Geology* had gone through nine of its eleven editions. So even Lyell, for most of his life, was not an evolutionist.

But all these men, creationists every one, held to our present-day ideas as to the order of succession of types of life on earth—to precisely that order, in short, that is now the most effective of all evidences for organic evolution. Of course they held to it: they were the people who worked it out.

In short, this oft-repeated statement that evolutionists arranged the order of events in geologic time is simply one whacking Fundamentalist Fib. In this, present-day evolutionists have simply taken what pre-Darwinian creationists have given them, adding only corroboration and detail.

A publication that does this sort of thing right along, and evidently deliberately, ought to rechristen itself. *Bible Champion* indeed! Champion something all right! But what?

EVOLUTION AND THE MURDER RATE

"In England, a Bible land," writes Revivalist Biederwolf in the most Fundamentalist of monthlies, the *Bible Champion* (Aug., 1929, p. 410) "there is only one murder to every 178,000 inhabitants. In Holland, a Bible country, there is only one murder to every 100,000 of the inhabitants. In Spain, where there is no Bible, there is one murder for every 4,113 inhabitants." The Reverend Dr. Biederwolf—as is the way with Fundamentalists and their facts—gives no authority for figures, but they seem correct thus far.

To put the same information in the more usual form for all statistics, in England, on the average, out of every hundred thousand persons, slightly more than half of one person gets murdered every year and in Holland just one flat, while in Spain the homicide rate is 24 per 100,000.

But alas for Dr. Biederwolf's reasoning—he stopped his figures much too soon! There may be no Bible in Spain in spite of unnumbered churches and priests; but Tennessee, U. S. A., is so much a Bible land that it was the first community in the entire world to pass laws against "unbiblical" Evolution—and Memphis, Tennessee, where sat the very first legislature that passed a "monkey-bill," according to the official statistics of the Prudential Insurance Company for 1928, 135 William Street, New York City; released for publication, March 14, 1929, has a murder rate of 60.5! So the metropolis of Fundamentalism and Anti-evolution actually is more than twice as murderous as Bibleless Spain, sixty times more wicked than Bible-criticising Holland, and 107 times more addicted to smashing the chief of the Ten Commandments than the land of Darwin, Huxley, and Spencer, where modern Evolution was born!

Moreover, the ten most criminal cities of the United States, with an average murder rate of 38.6 per 100,000, or half as much again as Bibleless Spain, *all are in the Bible Belt!* Even Chicago scores only 15.8, while New York, with its 6.7, is getting well down to a tenth of the murder rate of Bible-reading Memphis.

As for the great manufacturing cities of New England, where half the population is Roman Catholic and the rest splits between infidel and "modernist", where all educated persons for two generations have taken the ancestral monkey as a matter of course, these run about two annual murders per hundred thousand persons. Cambridge, the seat of Harvard University, where Evolution first entered the United States, scores 1.6; the Yale district, where they have lately opened a new museum devoted to proofs for Evolution, is down to 1.1. Several of these big cities do not appear in the Prudential statistics at all, because they had no murders in 1928. All these "teach evolution in the public schools" along with the multiplication table. But Memphis, where they do not teach Evolution, had that same year 115 murders, and Birmingham, Alabama, 122.

In short, the oft-repeated formula of the Anti-evolutionist, "Tell a man that he is the offspring of a brute and he will behave like one," works out actually—but just backwards. It is precisely the persons who think they were monkeys once who take special pains *not* to act like monkeys now. England, Holland, France, Germany, and the non-Fundamentalist parts of the United States average about one murder to the hundred thousand inhabitants, and below one per cent illiteracy. But in Fundamentalist districts, where "monkey-bills" just miss passing or go through with a rush, illiteracy runs 10 and 20 per cent; even some preachers—Anti-evolutionists to a man—cannot read or write; and the murder rate, highest anywhere on earth, is four, five and six times that average for even these murderous United States!

"By their fruits ye shall know them."

Who He Was

At least a dozen EVOLUTION readers have informed us regarding the "Dr. Etheridge of the British Museum" who is constantly quoted by fundamentalists as a renowned world authority and about whom we asked in our last issue.

He was an *assistant* in the Geology Department of the British Museum from 1881 ot 1891, *forty years ago,* and died in Australia at the age of 84 in 1903. Truly, it must be tough to have to go back that far to find a backer.

Funnymentals

"The man who teaches evolution is a plain perjurer, no matter whether he occupies a chair in the university or is just an ordinary intellectual tramp." Rev. Dr. Mark A. Mathews, First Presbyterian Church, Seattle, quoted by Seattle Times.

"We believe that the Genesis record of a literal creation in six twenty-four-hour days is an inspired record of a historical fact. We deplore the present tendency to interpret the past history of the earth in terms of long geological ages, for we maintain that the theory of evolution rests on unproved hypothesis, whereas the facts of science support not only the great fundamental doctrine of creationism but also the idea of the destruction of the world by the flood as portrayed in the Bible.

"We affirm that the variations occurring in plants and animals do not indicate evolutionary progress, but are clearly interpreted in the light of conditions prevailing since the flood, and we utterly repudiate the implication that man originated from any lower form of life." Resolution adopted by World Conference of Seventh Day Adventists (299,555 members) San Francisco, July, 1930.

"The time has come when bishops who believe the tommyrot of evolution and allow it to spread under their jurisdiction ought to be compelled to resign their office. Missionaries who teach it ought to be called home. Preachers who preach it ought to be made to vacate their pulpits. Professors who teach it in our Christian schools and colleges ought to be driven from the institutions. While editors who proclaim it through their papers ought to be silenced and their pens dried up. * * *

"There will never be another genuine revival of religion in this world until the Christian church repudiates the most subtle and monstrous lie that the devil has ever thrown in the face of the Son of God, and until it drives the whole diabolic spawn of evolution into the nethermost depths of hell where it belongs, when finally the Angel of the Apocalypse puts the lid upon the pit and bottles up the whole pestiferous tribe, there to await the final judgment of an insulted God." From "The Devil Unmasked," pamphlet published by San Antonio Bible Institute.

"Some may say, why not ignore evolution and let it die of neglect? This scheme might apply to a fierce dog, but evolution is far from a fierce dog character. It is more like a stealthy hyena in its habits." C. H. Buchanan, D.D., in Jan. 1930 Bible Champion.

"If we make a reasonable allowance for the work of the Deluge, or the Flood, we shall not have enough fossils left over, unexplained and unaccounted for, to make much of a showing toward a long age previously." George McCready Price in July, 1929, Bible Champion.

Evolution does not deal with biblical interpretation. However, to give our readers an idea of questions agitating the fundamentalist world we reprint this from the December 1930 "Christian Fundamentalist."

Three Views of Creation

By DUDLEY JOSEPH WHITNEY

There are among Bible believers three distinct views regarding the events of creation week. The first view is that taken by Doctor Riley: that the earth is ages old and that these ages correspond with the outline of creation as given in Genesis I so excellently that one is compelled to believe that these ages were the "days" of creation.

The second view was that taken by Mr. Rimmer: that the ages may have occurred and doubtless did occur, but that the earth underwent a complete ruin, then a reconstruction in literal days. An Italian scholar, G. Bartoli, has essentially the same view, only believes the earth before its ruin was a product of direct instant creation, rather than a development of long ages.

There is, however, a view distinct from both of these which has at the present time what seems stronger backing in science than either of the other theories, namely, that the stratified rocks and the fossils therein are the result of the Deluge and were not deposited during geological ages, or in a pre-Adamic ruin. This is the view so ably developed by George McCready Price, and accepted by many others who have made a careful study of the subject.

In the very nature of the case the days of creation according to this theory would not be geological ages, for no sign of such ages would be found in the rocks and, as a natural consequence, literal day creation would be believed.

The correct method of solving the problem would seem to be to see how well each of the *three* views of earth history harmonized with the Bible; then to see, too, how well they harmonized with true science—and true science does not mean the fanciful views commonly put forth by many men of standing as science.

Forty years ago and even less, striking harmony seemed to appear between historical geology as accepted by scholars and the first chapter of Genesis. This seemed to make belief in geological age "days" unavoidable. The view was that the primordial earth was very hot; the water now in the oceans was part of the atmosphere on account of heat; thus "the earth would be waste and void, and darkness would cover the face of the deep." A cooling would partially clear the atmosphere and let light penetrate, also the oceans to form; then would come a sequence of events, or of living things, as described in Genesis.

However, times have changed, knowledge has increased, and the apparent harmony between Genesis and what Prof. Price calls "evolutionary geology" has largely disappeared.

To begin with geologists no longer assert that the earth was a molten hot globe that gradually cooled, thus developing the history suggested in Genesis. They simply cannot tell the early conditions of the earth, though many believe that the earth started small and cool and grew to its present size and condition.

Again, Genesis asserts the covering of the earth with vegetation the third day and the creation of water living creatures, and of birds and "creeping things" on the fifth day. This would make one full day between the creation of vegetation and the creation of those animals lower than the beasts. Geology, however, has shell fish, and non-vertebrates of all leading types, filling the seas long before any signs of land vegetation appeared. Here, then, is a serious discrepancy between Genesis and geological ages. There are also other discrepancies. The apparent harmony between Genesis and standard theories of earth history is very general and indefinite. They agree in the *progress* from simple earth and simple living things up to the higher forms, but any real identification of definite "days" of creation with definite geological ages is virtually impossible.

Prof. Price and others who have adopted his views of earth history have completely discredited the doctrine of geological ages with every careful, honest student of geology and surely one should not wish to harmonize Genesis with bad science!

Let every person interested read carefully the Deluge account: see that awful rains and floods occurred for forty days, that the Ark was afloat for months after that and that it grounded on what is now some of the highest land in western Asia and that a full year and more from the start of the disturbance passed before the occupants of the Ark could issue forth on the land.

The obvious thing to decide is that the ruin we see was the ruin brought about by the Deluge. That is very simple and very natural; it clears the whole problem up, not only in theory, but in practical science. There is therefore no occasion whatever for trying to account for the fossils by any pre-Adamic ruin and actual science, too, is contrary to the doctrine of geological ages. If the rocks came through the Deluge and not through geological ages, literal day creation is the most reasonable kind of creation to accept.

The thing to believe about creation, as indicated both by the Scriptures and by true science, is the divine creation of an ideal earth (evidently in literal days) and the ruin of that earth by the Deluge. Upon the ruins of that earth we now live. There is no occasion to believe in geological age "days," and the evidence is against them.

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